Reissued March 4, 1910.

U. S. DEPARTMENT OF AGRICULTURE,
BUREAU OF PLANT INDUSTRY—Circular No. 31.
B. T. GALLOWAY, Chief of Bureau.

NOTES ON THE NUMBER AND DISTRIBUTION OF NATIVE LEGUMES IN NEBRASKA AND KANSAS.

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25450—Cir. 31—10 WASHINGTON : GOVERNMENT PRINTING OFFICE : 1910

BUREAU OF PLANT INDUSTRY.

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[Cir. 31]

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INTRODUCTION.

Many hypotheses have been formed to account for the large stores of nitrogen in virgin soils, but none of these have been entirely satisfactory. It seems to be a well-established fact that small quantities of ammonia are collected from the air by rain and added to the soil; also, that more or less nitric acid is formed by electrical discharges and added to the supply. Some investigators have attributed the fixation of nitrogen entirely to the latter cause. Recently a number of efforts have been made to show that nonsymbiotic or independent bacteria are the chief agents in fixing this element. While it seems certain that some nitrogen is added to the soil by each of these methods, it appears to the writer that there is not sufficient evidence to warrant a conclusion that any one of them has been the most important factor in this work. They do not furnish a satisfactory explanation of the presence of such large quantities of nitrogen in the soil.

NITROGEN FIXATION IN SOIL BY WILD LEGUMES.

Several experimenters have suggested that wild legumes may have played some part in this work, but they have not generally been considered as important factors. The studies reported in this circular indicate that this subject deserves more thorough investigation than it has yet received and that native legumes have been of much more importance in this rôle than has been thought.

Several years ago the writer raised the question whether the native legumes of the prairies were sufficiently numerous to have fixed the amount of nitrogen present. A search for published data on the subject was made, but none were found. Accordingly, in the spring of 1908 a series of investigations was begun, a preliminary report of which is here given.

DIFFICULTY OF MAKING INVESTIGATION.

Many difficulties were experienced in collecting the desired data. Not many tracts of virgin prairie remain in eastern Nebraska and northeastern Kansas, except on land that is too wet or too rough or stony to be easily farmed. Furthermore, most of the grass plots that do remain have been pastured so much that few legumes are left. It

was therefore necessary to search out the grass fields that had been pastured the least and which at the same time represented as nearly as possible the average farm lands of the region.

The next difficulty arose in the fact that the growing season of the different species is very different. Some species of the genus Astragalus, for example, are in fruit by May and often dead before July. Lotus does not come up until late, and the Psoraleas do not all show their sprouts until about the middle or end of May, and by the first of August they begin to break off just below the surface of the soil and to blow away. Other species are not readily recognizable till late in the season. From this it will be seen that anyone making counts will seldom find all the legumes at any one time.

A third difficulty presented itself in the irregular distribution of the plants. It was not easy to find areas that represented average conditions. Not only was there a natural source of error here but a personal one also. Having selected a piece of land that fairly represented a certain soil and slope it was then necessary to select the plots to be counted. Here the personal equation appeared. With the amount of time available it was not feasible to count large areas, so the square yard was selected as the unit. If a patch contains showy legumes one is almost sure to select plots that either have none of these plants or have an unusual number. To avoid this unintentional selection the following methods were employed: With eyes closed the writer would walk a certain number of steps which would take him to a point he knew he had not seen. For example, he determined to walk 100 paces south and take his hundredth heel mark as the northwest corner of his first square yard, or he walked backwards to a point he had not seen and marked the plot to be counted in the same way. Either of these methods gave him square yards selected purely at random. It was not practical to use the English method of throwing a hoop, and even if this could have been done it is doubtful if any advantage would have been gained thereby.

With many legumes, especially Amorpha (shoe-string), Kuhnistera (prairie clover), and several of the Psoraleas (in some places called wild alfalfa), it is often impossible to tell whether there is one large plant or several plants grouped together. In cases where there was much doubt the group was always considered as a single plant.

For the reason stated it is plain that the counts given in the following table must be under rather than over the real number of legumes present on the plots counted. It should also be noted that several of the counts were made before the legumes had all come up. It was hoped that several times as much data could be collected during the year, but the difficulties mentioned, together with the fact that much of the season had to be spent in the semiarid region, limited the work greatly.

TABLE I.—*Number of native legumes on certain plots in Nebraska, Kansas, and Colorado.*

Place.	Exposure.	Soil.	Dominant plants.	Date of count.	Size of plot.	Legumes.		Remarks.
						Number.	Average per sq. yd.	
EAST OF 100° WEST LONGITUDE.					*Sq. yds.*			
Crab Orchard, Nebr.	Gentle southern slope.	Marshall loam.	Bluestem.	Apr. 22	3	69	23	Psoraleas not up.
Do.	do.	do.	Bluestem and bunch-grass.	do.	3	92	30.67	Do.
Falls City, Nebr.	River bottom.	Wabash silt loam.	do.	Apr. 27	1	74	74	Do.
Lewiston, Nebr., 3 miles southeast.	Gentle slope.	Marshall loam.	do.	June 4	5	144	28.6	
Lewiston, Nebr.	Gentle western slope.	Marshall silt loam.	do.	do.	3	45	15	
Dunbar, Nebr.	Gentle southern slope.	do.	do.	Apr. 29	3	63	21	Psoraleas not all up.
Holdrege, Nebr.	Level.	do.	do.	July 10	8	106	13.25	
Do.	do.	do.	Buffalo grass, some of bunch-grass.	do.	4	59	14.75	Pastured by lariating cow.
Do.	do.	do.	Wheat-grass and sedge.	do.	3	5	1.67	
University Place, Nebr.	do.	do.	Bluestem and bunch-grass.	July 2	7	134	19.14	
Mason City, Nebr.	Top of hill in cemetery.	do.	Buffalo grass, grama grass, bluestem, and bunch-grass.	Aug. 14	10	70	7	
Mason City, Nebr., 10 miles south.	Gentle western slope.	do.	do.	Aug. 15	2	53	26.5	Pasture.
Havelock, Nebr.	Level.	do.	Bluestem.	Aug. 21	5	64	12.8	
Osage City, Kans.	do.	Crawford silt loam (?).	Bluestem and bushy bluestem.	May 15	3	44	14.67	
Total.					60	1,022	17.03	
HIGH PLAINS.								
Bucklin, Kans.	Level.	Marshall silt loam (?).	Buffalo grass.	May 16	3	3	1	
Do.	do.	do.	do.	do.	4	19	4.75	
Do.	do.	Finny fine sandy loam.	Buffalo grass and bunch-grass.	do.	4	17	4.25	
Madrid, Nebr.	Valley.	Marshall fine sandy loam.	Buffalo grass.	July 17	1	20	20	
Do.	do.	Fine sandy loam.	do.	do.	8	14	1.75	
Total.					20	73	3.6	
SAND HILLS.								
Madrid, Nebr.	Near top.	Sand hill.	Mixed.	July 17	9	63	7	
Wray, Colo.	Top northern slope.	do.		July 12	3	69	23	
Do.	Top southern slope.	do.		do.	2	9	4.5	
Do.	In eastern valley.	do.		do.	2	5	2.5	
Hyannis, Nebr.	Top.	do.		Aug. 3	5	30	6	
Total.					21	176	8.4	

That part of Table I referring to the country east of 100° west longitude is believed to be fairly representative of average conditions. The parts referring to the high plains and the sand hills are so meager as to be only suggestive. The counts made on the high plains were all at the eastern border and were either on loess or at the transition from that to the tertiary. Farther west many observations were made, but legumes are much fewer, and the counting of much larger areas would have been necessary to get results at all reliable. Here too, the desiccation of many plants in the summer makes it very difficult to secure accurate counts.

LEGUMES FORM A LARGE PART OF OUR NATIVE FLORA.

The writer had long been familiar with the flora of this region, but was not at all prepared for such results as are shown in the table. After the grasses (including sedges) and possibly the composites, legumes form a larger part of our flora than does any other group of plants.

If these figures are representative or anywhere near it, it is evident that our farm lands from time immemorial have been growing a full stand of legumes. Seventeen plants to the square yard are enough to fill all the soil with their roots. Most of these plants, such as Amorpha, Kuhnistera, and Psoralea, have enormous root systems (and these genera represent the large majority of the prairie legumes). A single plant is often sufficient to fill the soil with its roots for a radius of several feet, as any farmer who has plowed up Amorpha is ready to testify. The smallest root systems are probably those of Vicia and Lotus, and yet seventeen of these to the square yard would seem to be sufficient to gather a large supply of nitrogen.

NODULES ABUNDANT IN WILD LEGUMES.

Many examinations were made to ascertain the prevalence of nodules upon different species. Large numbers of tubercles were found on every species examined and on nearly every individual, except mature Kuhnistera. Nodules are especially plentiful on Psoralea, Astragalus, Acuan, Meibomia, and Lotus. On Lotus the nodules are often almost massed together on the taproot. Some difficulty was experienced at first in finding tubercles on Kuhnistera, but they are always in evidence on seedlings. On the old plants there is doubt whether typical nodules are produced or whether the bacteria are in the small, thickened roots which occur in extraordinary numbers, almost in fasicles, especially on roots of the previous year's growth. During the coming season an effort will be made to determine this point. The efficiency of these legumes as nitrogen gatherers does not seem to be open to question, however, if the universal inoculation of the seedling plants is considered.

FACTORS INFLUENCING THE DISTRIBUTION OF WILD LEGUMES.

The distribution and abundance of legumes are influenced by many factors, one of the most marked of which is the adaptability of the locality for the production of heavy crops of grass. Few legumes can compete with a thrifty growth of grass. Where *Andropogon furcatus* (bluestem) luxuriates, few legumes except Psoralea seem to be able to persist.

On the densest swards of *Bulbilis dactyloides* (buffalo grass), Vicia, Psoralea, Lotus, and Astragalus are occasional habitants, but none of them are able to constitute a very large proportion of the plant growth. On poor soils and slopes where the grass is thin, both the number of individuals and the number of species of leguminous plants are usually greater than on rich soils and level tracts, and legumes consequently form a very much larger proportion of the flora. But on all soils and in all climates of the region legumes peculiarly adapted to the conditions are present in large numbers.

In many of the meadows in the river valleys of Iowa, South Dakota, and northeastern Nebraska, *Crotolaria sagittalis* covers most of the ground. On level sand beds near streams Acuan grows in profusion, and on thinly grassed sandy bottoms *Cassia chamaecrista* (partridge pea) is often abundant. On many low sand hills Psoralea is almost the only habitant, while on the tops of sand hills where there is little vegetation *Phaca longifolia* is preparing the way for more plant growth and is often assisted in this work by *Kuhnistera villosa* and several other species.

LEGUMES ARE CROWDED OUT ON THE RICHEST SOILS.

It does not seem that most of these legumes choose the poorer soils, for, in fact, many of them grow much better on rich soil, but when the soil becomes rich in nitrogen and humus other plants which do not thrive on poor soil are able to crowd out the legumes. There is good reason to believe that lands that are now richest formerly supported the densest leguminous growths, except, perhaps, where the fertility has been washed down from higher levels.

NUMBER OF GENERA AND SPECIES IN DIFFERENT LOCALITIES.

While the number and distribution of individuals on arable lands, and not the number and distribution of genera and species in the State, is the important factor for our purpose, yet this latter question deserves mention. Pound and Clements[a] give 23 genera and 103 species of legumes as occurring in Nebraska. There are 23 of the species characterized as inhabitants of low prairies and meadows, which constitute most of the farm lands, 36 of high prairies, sandy bluffs, and

[a] Phytogeography of Nebraska, p. 240.

sand hills, and 16 of western table-lands and foothills. Only a few of these are abundant and widely distributed.

Of the 1,022 plants included in the table of legumes east of 100°, 340 are Kuhnistera, 333 Psoralea, 185 Amorpha, 77 Vicia, 67 Lotus, 12 Astragalus, 4 Lespedeza, 3 Aragallus, and 1 Baptisia.

With the possible exception of Astragalus, Psoralea is the most widely and evenly distributed genus in the State and has probably been the most effective in fertilizing the soils, closely followed by Kuhnistera and Amorpha, while Astragalus has been an important factor in all localities. *Astragalus crassicarpus* (ground plum) was formerly so abundant as to tinge whole prairies with the color of its flowers, but is now almost extinct in many sections. In much of the western half of the region Lotus has been very important.

VALUE OF LEGUMES IN PASTURES.

The value of the native legumes lies not alone in their ability to store nitrogen in the soil, but in their feed value also. Live stock always do better in new pastures than in old ones unless tame grasses have come in. It seems fair to assume that this difference is partly due to the greater portion of leguminous forage plants in the new pasture, giving a better balanced ration.

Many of the legumes are so ravenously eaten by stock as to be exterminated in a short time. *Astragalus crassicarpus* is one of the first to disappear. Cattle do not seem to relish Psoralea and Kuhnistera in new pastures, but after the more palatable legumes are gone these, too, are eaten and disappear, although their vigorous root systems enable them to endure a long time. So far as the writer is aware, *Baptisia bracteata* (false indigo, lead plant) is the only native legume that is able to maintain itself in pastures. This does not seem to be eaten by stock, for it thrives in pastures even where feed is scarce.

LESSON OF THE PRAIRIE LEGUME FOR THE FARMER.

Western farmers have been slow to learn their lesson from nature. Nature on her farm has kept up the production of grasses and other nitrogen robbers by the constant growth of legumes. If this fact had been recognized sooner perhaps there would not have been such reckless exploitation of the rich soils of the Mississippi Basin. For forty years farmers have lost sight of this and have taken off grain crops (all grasses) continuously and doubted if this practice would ever exhaust their soils, because they were still productive after the removal of twenty, thirty, or forty crops. But now the effect is evident; farmers must learn from the prairies around them one of the first principles of permanent agriculture and introduce leguminous crops into the farm rotation.

WILD LEGUMES IN THE EASTERN UNITED STATES.

After this paper was prepared the writer's attention was called to Bulletin No. 100 of the Maryland Agricultural Experiment Station, the pertinent parts of which are quoted below. It was a surprise to find such close agreement between observations made in two States where conditions are so different.

The wild plants of this kind (legumes), next to grasses and composites, form a larger part of our native flora than any other family of plants. * * * Their protein content is usually high and they also then make most useful feeding stuffs. (P. 97.)

Practically all of the wild Maryland species examined have tubercles on the roots. (P. 100.)

But when we consider the large areas of uncultivated land in Maryland where no crop is or will be grown under present conditions, the value of wild legumes in building up such land by adding humus and nitrogen becomes much more worthy of consideration, especially if we remember the fact that most of our waste woodland and fields are covered with a natural growth of leguminous plants doing their work without a particle of labor on the part of the owner. On many thousand acres of waste land over one-half of the weed growth is composed of nitrogen-gathering leguminous plants. * * * A great many of these species grow with the greatest ease on dry, sandy, or sterile land where other plants would not succeed until legumes had opened the way. (P. 100.)

Legumes of some kind are in every climate and soil. In many parts of Maryland legumes form one-fourth to three-fourths of the wild plants. (P. 106.)

Approved:

JAMES WILSON,
Secretary of Agriculture.

WASHINGTON, D. C., *April 23, 1909.*

[Cir. 31]

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